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TRACE ELEMENTS IN METAMORPHIC AND GRANITOID ROCKS OF THE BASEMENT IN THE CENTRAL DANUBE—TISZA INTERFLUVE (HUNGARY)

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ABSTRACT

Trace elements of the metamorphic and granitoid rocks of the Kiskunhalas—Tázlár—Szank—Jászszentlászló region lying in the central part of the Danube—Tisza Interfluve were studied. By means of the trace element diagrams the trace element distribution of different rock types can be compared and the premetamorphic rocks can be identified with satisfactory approximation, as well. In the region in question the gneisses are of pelitic, the amphibolites of basis igneous origin, with high probability. Migmatitization and milonitization did not cause considerable changes in the trace element compositions of the rocks. The trace element distribution pattern of granitoids remarkably differs from that of the metamorphic rocks.

Keywords: metamorphic rocks, granitoid rocks, trace element geochemistry, petrogenesis.

INTRODUCTION

The basement of the central and southern part of the Danube — Tisza Interfluve consists predominantly of non-equilibrium rocks. Tectonically, the Danube — Tisza-Interfluve is dissected by a dislocation line of roughly W—E direction into two parts (JUHÁSZ, 1966). North of this line only a few data are available while the basement of the southern one has been explored by numerous hydrocarbon exploration wells. In this latter region different metamorphites (mica schists, gneiss, granite-gneiss, amphibolite) are found that based on their variegated texture can be grouped, as well (e.g. milonites, phyllonitic milonites, see SZEPESHÁZY, 1966). In the subsequent comprehension of the Hungarian Oil and Gas Trust (JUHÁSZ, 1969) the rock groups of the regions are represented by: a) granite and associated magmatites; b) paleovolcanites and paleo-subvolcanites; and c) metamorphites. Based on the metamorphic grade and compositional differences, the latter ones can be divided into subgroups. In this comprehension the trace elements are discussed also according to this classification but no petrogenetic conclusions are drawn. The metamorphites underlying the Cenozoic or Mesozoic formations can be identified as the metamorphites of highest age in the Carpathians (SZEPESHÁZY, 1973).

Based on the mineral paragenetic studies, on the composition zoning and element partition ratios of the rock-forming minerals a three-phase evolution model was established (ÁRKAI *et al.*, 1975, 1977). The metamorphic basement of the Danube — Tisza Interfluve consists of strips of SW-NE direction (SZALAY, 1977a, 1977b) the development of which is related to three tectonometamorphic cycles (in this sense the studied area belongs to the central strip consisting of polymetamorphic gneisses and amphibolites).

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In harmony with the comparative petrological investigations (CSEREPES-MESZÉNA, B., 1980) in the formations of the Danube — Tisza Interfluve older than Carboniferous two formations can be distinguished: the Kecskemét Formation (the Soltvadkert region belongs to this unit) and the Jászszentlászló Formation (in the area in question the Kiskunhalas — Szank — Jászszentlászló region represents this unit).

Based on up-to-date analytical methods two main groups, i.e. anchimetamorphites and polymetamorphites have been distinguished (ÁRKAI, 1978, 1980, 1981) The trace element analyses of these works were carried out by myself and this will be discussed below having accepted the nomenclature and terminology elaborated so far (ÁRKAI, 1981).

My studies aimed the characterization of the metamorphic and granitoid rocks according to their trace element concentrations as well as the determination of the premetamorphic rocks based on the trace element composition and changes, respectively.

SAMPLES AND METHODS

119 samples of 70 boreholes of the Kiskunhalas — NE, Tázlár and Szank — Jászszentlászló regions *(Fig. 1)* were studied (including two granite samples from the Soltvadkert area). The determination of the mineral composition as well as the petrographic description were carried out earlier (ÁRKAI, 1978, 1980, 1981).

Trace elements (B, Co, Cr, Ga, Mn, Ni, Pb, Ti, V and Zn) were determined by means of emission spectrography (PGS — 2 type Zeiss spectrograph).

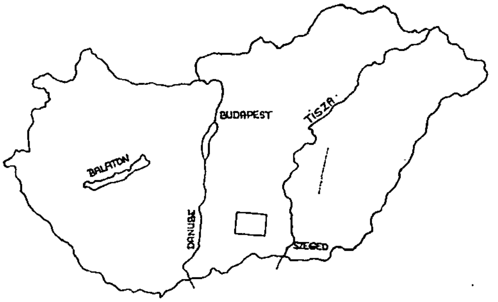

Fig. 1. Geographical setting of the studied region

Recording conditions: grate position: 6.22; split: 15 microns; blende: 2; nominal amperage: 7 A; exposition time: 164 s; electrodes: Al 9999; collimator: 10.6; electrode distance: 1 mm; arc source: BIG — 100 AC generator; plates: AGFA GEVAERT 23D56; development: AGFA — L at 20 °C, 5 min.

Evaluation: at least three records were made from each sample. Quantitative evaluation was made based on comparative standards (GM granite and TB clay from the Staatsekretariat für Geologie, Berlin) and on internal standards determined by chemical analyses (AAS). The maximal deviation proved to be ±15 percent, the ranges of measurements are given in Table 1.

TABLE 1

Trace element contents of the rocks of the Kiskunhalas-NE region (ppm)

Rock unit		B	Co	Cr	Ga	Mn	Ni	Pb	Ti	V	Zn
Measurement range (ppm)		5—500	3—500	1—500	3—500	20—2500	5—500	5—500	50—7000	5—500	10—500
Quartz-phyllite (4)	$\bar{x}$	82	42	181	35	158	18	11	4037	46	53
	s_k	11	35	123	14	141	8	7	1850	29	40
Carbonate-phyllite (7)	$\bar{x}$	147	45	172	48	306	97	72	2925	148	122
	s_k	87	31	126	31	395	99	79	2018	114	118
Chloritic muscovite-gneiss (6)	$\bar{x}$	54	43	134	50	224	91	26	5765	157	134
	s_k	22	31	79	22	67	102	22	1030	131	82
Chloritic muscovite-biotite-gneiss (10)	$\bar{x}$	59	34	209	71	346	38	12	6670	93	74
	s_k	21	18	86	28	352	43	7	480	11	30
Chloritic muscovite-gneiss (19)	$\bar{x}$	64	21	208	56	167	18	11	5170	73	60
	s_k	21	11	95	21	88	8	7	1980	46	31

Note: s_k = denotes the corrected deviation

TABLE 2

Trace element content of the rocks in the Tázlár region (ppm)

Rock unit		B	Co	Cr	Ga	Mn	Ni	Pb	Ti	V	Zn
Carbonate-phyllite		160	10	295	41	2500	135	36	4300	105	83
Chloritic biotite-gneiss (12)	$\bar{x}$	46	28	183	29	1260	67	39	5500	135	102
	s_k	25	19	68	11	1055	35	23	1950	78	46
Migmatitic biotite-gneiss (1)		30	16	140	36	320	57	54	6430	65	150
Amphibolite (1)		33	53	295	40	925	98	32	6330	305	155

TABLE 3

Trace element contents of the rocks from the Szank region (ppm)

Rock unit		B	Co	Cr	Ga	Mn	Ni	Pb	Ti	V	Zn
Muscovite-gneiss (2)	$\bar{x}$	24	18	148	35	453	92	24	4750	235	26
Chlorite biotite-muscovite-gneiss (7)	$\bar{x}$	21	26	159	25	591	68	25	5865	300	40
	s_k	8	14	85	9	197	56	13	2055	138	27
Biotite-gneiss (22)	$\bar{x}$	19	24	120	29	1023	80	17	6180	285	54
	s_k	7	18	80	29	600	72	11	1208	91	81
Granite (2)	$\bar{x}$	10	104	59	62	437	15	46	992	39	41
Amphibolite (11)	$\bar{x}$	20	57	144	18	1635	139	10	6100	254	72
	s_k	6	31	99	11	430	128	3	1690	110	60

TABLE 4

Trace element contents of the Szank-gneisses taking into account the garnet content and the subsequent effects (ppm)

Rock unit		B	Co	Cr	Ga	Mn	Ni	Pb	Ti	V	Zn
Non-migmatitic biotite-gneiss (12)	$\bar{x}$	21	25	136	24	1190	80	19	5960	292	65
	s_k	7	23	76	9	600	63	12	1400	96	107
Migmatitic biotite-gneiss (10)	$\bar{x}$	15	23	102	34	1025	65	16	6450	277	40
	s_k	4	8	85	31	456	88	11	930	88	33
Garnetiferous biotite-gneiss (8)	$\bar{x}$	17	38	126	28	1010	60	20	5990	315	47
	s_k	5	39	55	21	400	47	15	2400	130	24
Milonitized biotte-gneiss (8)	$\bar{x}$	23	18	135	100	760	82	15	4925	234	22
	s_k	10	13	89	78	365	62	8	1875	97	13
Migmatitized biotite—, muscovite- and muscovite-biotite-gneiss (16)	$\bar{x}$	18	24	113	32	870	73	21	6090	264	37
	s_k	8	11	77	34	420	72	12	1485	89	29

TABLE 5

Trace element contents of the rocks from the Soltvadkert—Jászszentlászló region (ppm)

Rock unit		B	Co	Cr	Ga	Mn	Ni	Pb	Ti	V	Zn
Soltvadkert granite (2)	$\bar{x}$	21	97	102	36	191	24	29	5950	86	14
Jásszentlászló-granite (7)	$\bar{x}$	13	97	54	52	222	26	48	2580	82	55
	s_k	2	76	46	6	149	24	13	1795	41	27
Migmatitic biotite-gneiss (1)		15	30	168	25	890	110	11	5300	365	18
Biotite-gneiss (1)		17	22	138	30	915	30	20	4000	200	70
Amphibolite (2)	$\bar{x}$	12	78	253	20	2220	390	8	5900	310	170

RESULTS

The trace element concentrations of 46 samples from 18 boreholes of the Kiskunhalas — NE region are found in Tablel, those of 15 samples from 12 boreholes of the Tázlár region in Table 2, those of 44 samples from 27 boreholes of the Szank region in Tables 3 and 4, finally the trace element data of 13 samples from the Soltvadkert — Jászszentlászló region are demonstrated in Table 5.

Formations of lowest metamorphic grade are represented by quartz-phyllites (Kiskunhalas) and by carbonate phyllites (Kiskunhalas and Tázlár). Based on their trace element contents the (carbonatic) quartz-phyllites considerably differ from the carbonate phyllites their trace element concentrations being much lower. The carbonate phyllites of the two regions are similar and based on their trace element contents may represent the same rock type.

Muscovite gneisses are found essentially in the Kiskunhalas region, the Szank samples (2 pieces) are somewhat more abundant in trace elements (e.g. Mn, Ni, Pb and V) only their Zn concentrations are lower than that of the Kiskunhalas samples. Due to the rather high concentration differences the formations of the two regions cannot be regarded to be the same. Nevertheless, in harmony with the fact that the formations of the Szank region are usually always of higher trace element amounts, these will be discussed together.

Among the biotite-gneiss samples of the tree regions the V, Zn and Mn values show the highest dispersion. In spite of this and based on the similarities in their mineral composition these rocks will be dealt with as one unit.

No amphibolites are found in the Kiskunhalas region, in the Tázlár area only one borehole revealed amphibolite. The amphibolites of Szank and Jászszentlászló are rather similar, except their Zn-contents. The Tázlár samples show higher Ga and Pb contents as compared with the two other regions. By all means, the amphibolites of the three regions are more or less similar, disregarding some smaller differences.

Granites are found only in the Szank and Jászszentlászló areas lying north-northeast of the Kiskunhalas and Tázlár regions. The granites of the two regions are conspicuously similar.

Premetamorphic rocks

Based on petrological-geochemical data efforts were made to determine the characteristics of the premetamorphic rocks (Árkai, 1978, 1980, 1981). Due to the small number of samples, in each region the premetamorphic starting rocks were only probabilized, except amphibolites the major part of which proved to be of mafic igneous origin.

It can be stated that. in spite of the smaller deviations or differences, the individual rock types can be considered to be the same rock type afiected by local alterations. In this sense I try to reconstruct the premetamorphic rocks on the basis of their trace element contents.

The different gneiss varieties derive with high probability from sedimentary, first of all from pelitic rocks. In *Fig. 2* the trace element composition of the biotite-gneisses and muscovite-biotite-gneisses are compared with the mean values of the clayey and basic igneous rocks (Turekian and Wedepohl, 1961). Except the values of Co and Ga the trace element concentrations are close to the clayey composition. The Co-content showing sometimes anomalously high values may be due to granitization (the Co concentrations of granites are very high as compared to the granitic

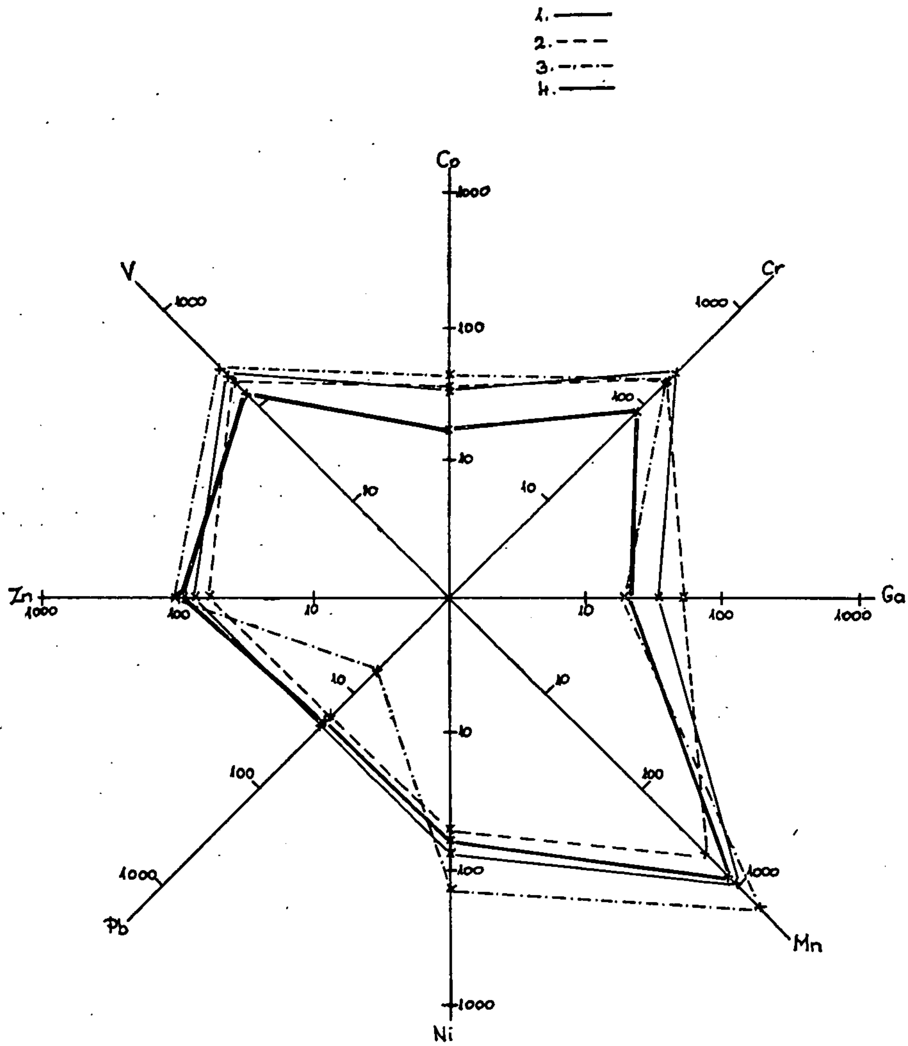

Fig. 2. Trace element composition of biotite-gneisses (1), muscovite-biotite-gneisses (2) as compared to the basic igneous average (3) and clayey average (4) of TUREKIAN and WEDEPOHL (1961)

average). The rocks are characterized always by higher Ga contents than usual, thus when deciding the origin of the rocks the Ga-values were neglected.

In case of the Szank—Jászszentlászló—Soltvadkert region the trace elements of the biotite-gneiss group and of granites are demonstrated *(Fig. 3)* and the average values of TUREKIAN and WEDEPOHL (1961) are also shown. There is no siignficant difference between the non-migmatitic and migmatitic biotite-gneisses, thus migmatitization itself did not cause remarkable change in the trace element concentrations. The process of granitization conspicuously increased the Co, Ga and Pb, and decreased the Mn, Ni and V concentrations. The Cr and Zn value do not show changes. In harmony with these data, the clayey origin comes to the lamelight again.

Several methods are available to determine the origin of amphibolites, though not all of them proved to be suitable in case of amphibolites of the region in question. E.g. the ' diagrams constructed after VAN DE CAMP (1969) and based on the Ni-mg and Cr-mg values of BURRI and NIGGLI (1945), referring to the origin of eruptive basic rocks, proved to be unsuitable to determine the premetamorphic rocks.

In the V-Cr discrimination diagram constructed after SCHWEDER (1968) the average values computed for all amphibolites are located unambiguously in the ortho-field, close to the zone of migmatitic amphibolites but outside the sedimentary range

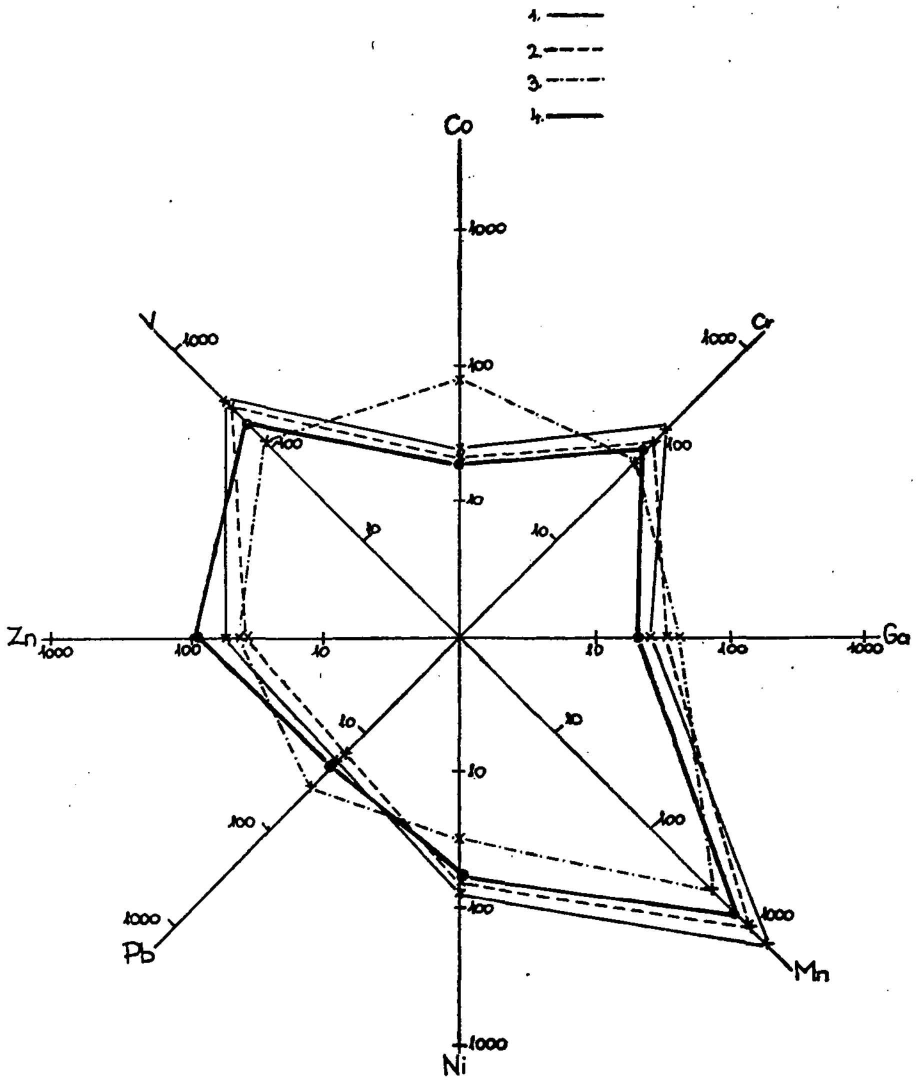

Fig. 3. Trace elements of non-migmatitized biotite- gneisses (1), migmatitized biotite-gneisses (2), granites (3) and the clayey average (4) of TUREKIAN and WEDEPOHL (1961)

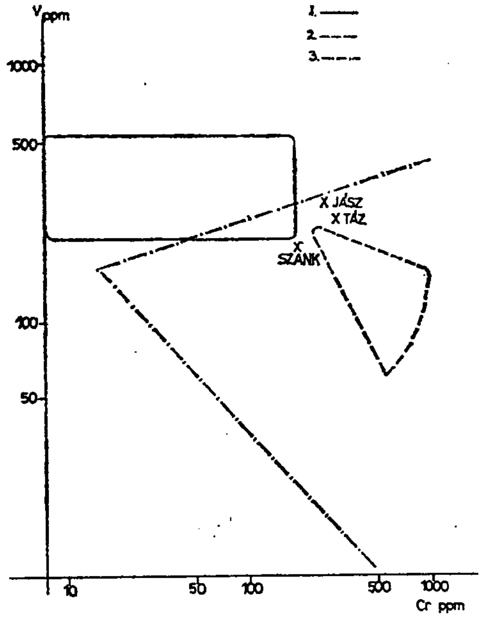

Fig. 4. Average values of amphibolites in the V-Cr discrimination diagram of SCHWEDER (1968), 1 — para-/sedimentary/amphibolites, 2 — migmatitic amphibolites, 3 — ortho-/basic igneous/-amphibolite.

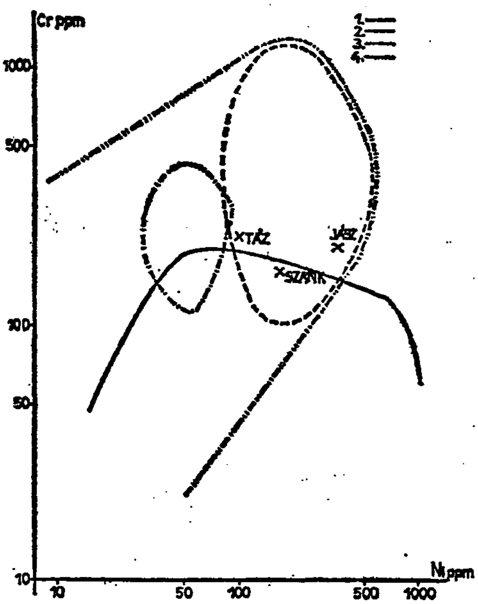

Fig. 5. Average values of amphibolites in the Cr-Ni discrimination diagram of WALKER *et al.* (1960). 1 — clays, 2 — ortho-/basic igneous/-amphibolites, 3 — para-/sedimentary/-amphibolites, 4 — migmatitic amphibolites

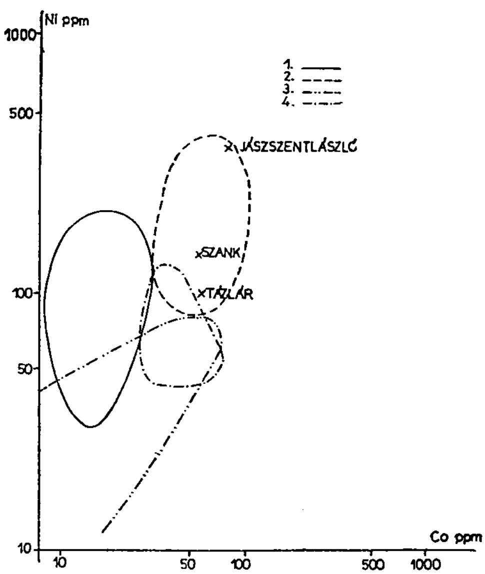

Fig. 6. Average values of amphibolites in the Ni-Co discrimination diagram of WALKER *et al.*, (1960). 1 — clays, 2 — ortho-/basic igneous/-amphibolites, 3 — para-/sedimentary/-amphibolites, 4 — migmatitic amphibolites

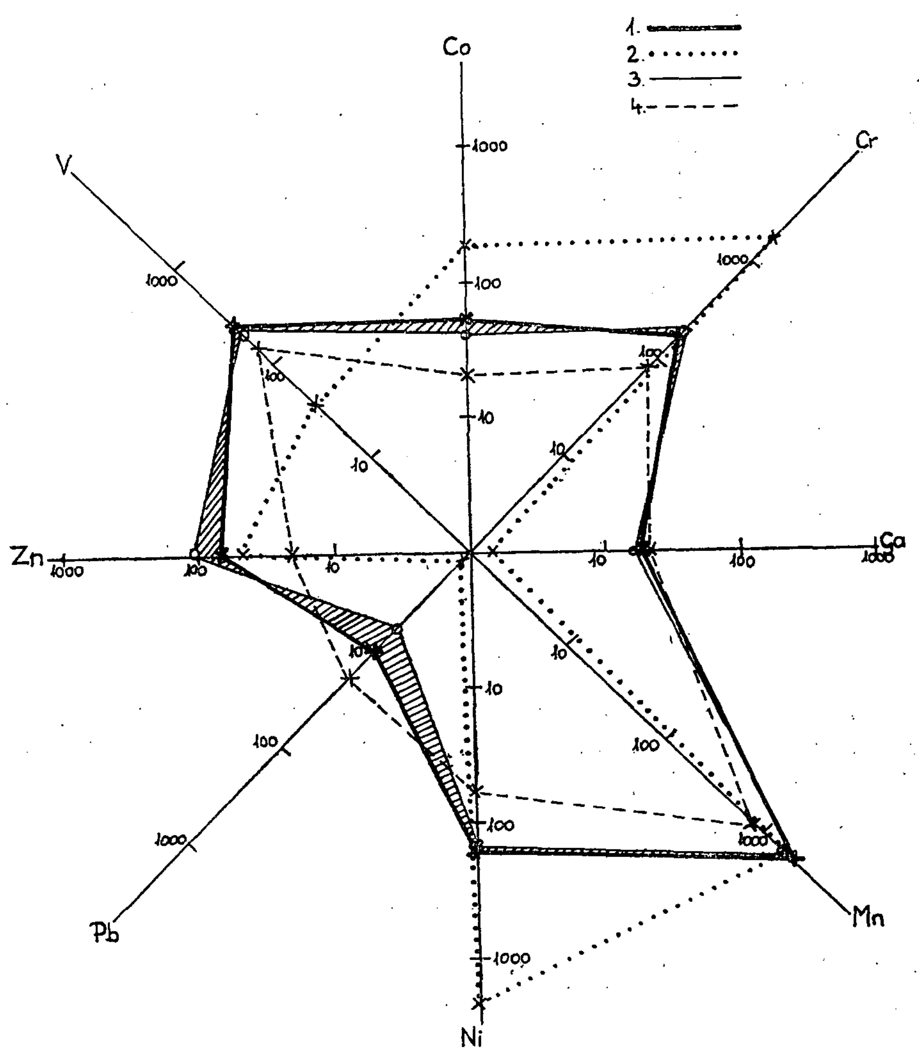

Fig. 7. Average trace element composition of amphibolites from the Szank—Jászszentlászló—Soltvadkert region (1) as compared to the average values of ultrabasic rocks (2), basic igneous rocks (3) and clays (4) of TUREKIAN and WEDEPOHL (1961).

(Fig. 4). In the Cr-Ni discrimination diagram *(Fig. 5)* constructed after WALKER *et al.*, (1960) there is some uncertainty due to the overlapping of the sedimentary field, but according to the Ni-Co discrimination diagram *(Fig. 6)* the amphibolites fall to the ortho-field, i.e. are of igneous origin.

In *Fig. 7* the trace element concentrations of amphibolites of the Szank—Jászszentlászló region are demonstrated for the ultrabasic, basic igneous and clayey sedimentary rocks in addition to the average values given by TUREKIAN and WEDEPOHL (1961). The ultrabasic origin can be fairly well excluded and except the Ga-values none of the elementary concentrations refer to clayey origin, i.e. the distribution of the total trace element contents indicates basic igneous origin.

CONCLUSIONS

Based on the trace element investigations carried out in the Kiskunhalas—Tázlár—Szank—Jászszentlászló—Soltvadkert region, concerning the metamorphic and granitoid rocks it can be stated that

— the applied trace element discrimination diagrams are suitable to compare the trace element contents of different rock types on the one hand, and are suitable to identify with good approximation the premetamorphic rocks, on the other;

— the different gneiss types of the region are most probably of sedimentary, i.e. of pelitic origin;

— the amphibolites are of igneous (basic igneous) origin, this statement reinforcing the previous conslusions;

— migmatitization in itself did not cause considerable change in the trace element contents of the rocks;

— milonitization is represented by textural and/or mineral compositional alterations, the trace element distribution pattern shows no remarkable change due to this effect;

— granitization concentrated certain elements (e.g. Co) independently of the type of the granitization process.

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